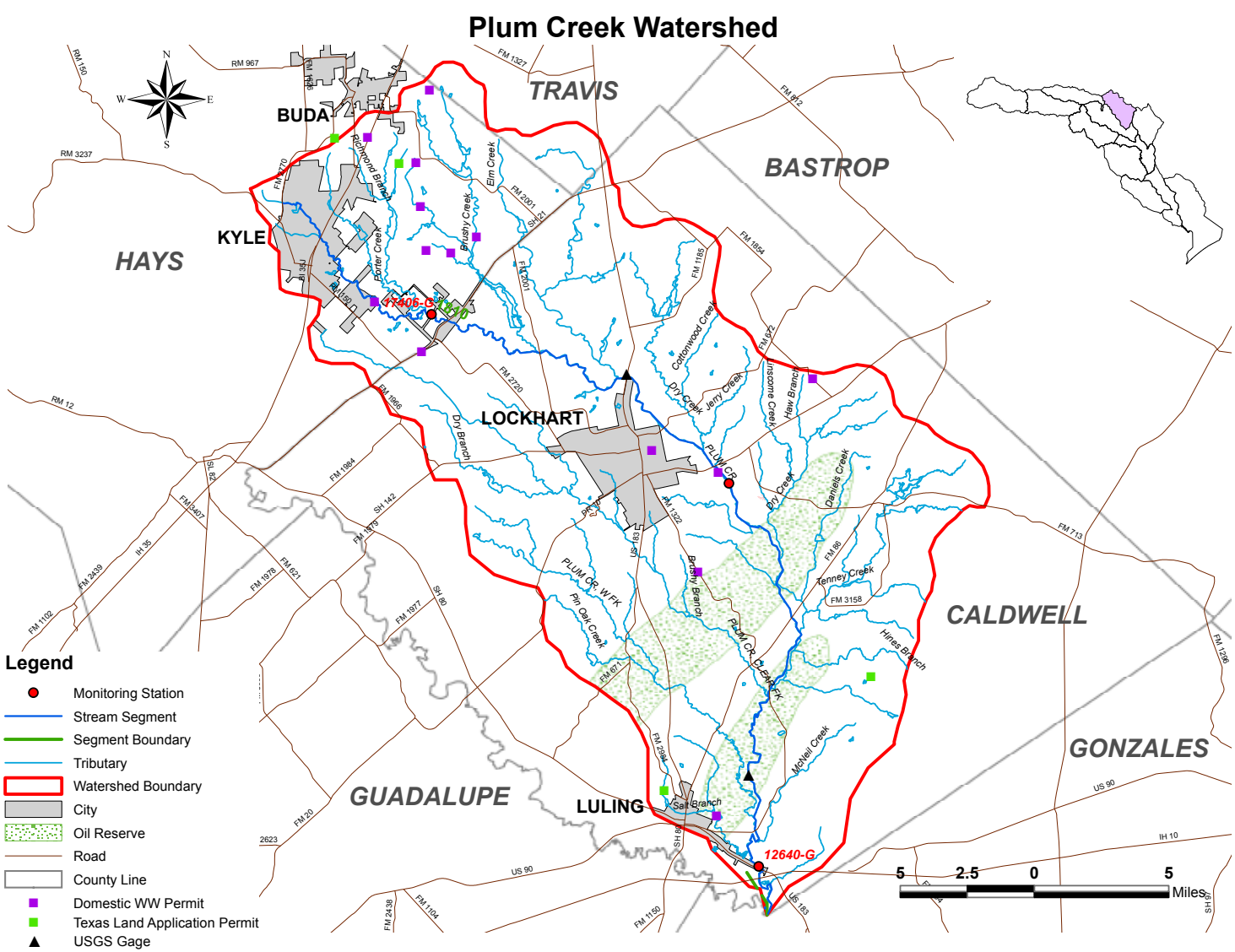

Monitoring Stations – Plum Creek

17406-G	Plum Creek at Plum Creek Road near Uhland
12647-T	Plum Creek at CR 202, Old McMahon Bridge, downstream of Lockhart
12640-G	Plum Creek at FM 135, near Luling

Sampling sites are labeled in red followed by the letter G (GBRA), T (TCEQ), U (UGRA) or W (Wimberley) indicating who is the monitoring entity.

Plum Creek Watershed

Drainage Area: 397 square miles

Streams and Rivers: San Marcos River, Plum Creek, Clear Fork Creek

Aquifers: Edwards-Balcones Fault Zone, Carrizo Wilcox

River Segments: 1810

Cities: Kyle, Buda, Uhland, Luling, Lockhart

Counties: Hays, Travis, Caldwell

EcoRegion: Texas Blackland Prairies, Post Oak Savannah

Vegetation Cover:

Deciduous Forest - 23.6%
Pasture/Hay- 22.9%
Grass/Herbaceous - 22.4%
Row Crops - 14.4%
Shrublands - 11.4%

Climate:

Average annual rainfall: 33 inches
Average annual temperature: January 40° July 95°

Land Uses: Industry, Urban, Oil & Gas Production, Cattle, Hog and Poultry Productions, Agriculture Crops (sorghum, hay, cotton, wheat and corn)

Water Body Uses: Aquatic Life Use, Contact Recreation Use, General Use, Fish Consumption Use

Soils: Black, waxy soil to sandy soil, limestone to black waxy chocolate and grey loam

Permitted Wastewater Treatment Facilities:

Domestic: 10
Land Application: 0
Industrial: 0

Plum Creek, Segment 1810, has its headwaters in Hays County near the city of Kyle. The creek travels through Hays and Caldwell Counties and confluences with the San Marcos River near the city of Luling. The stream has been assessed by TCEQ and is listed on the 2008 draft Texas Water Quality Inventory as impaired for bacteria, with concerns for nutrients, including nitrate nitrogen, ammonia nitrogen, orthophosphate and total phosphorus. Additionally, it is listed with a concern for dissolved oxygen at the minimum grab concentration of 3.0 milligram per liter (mg/L). The stream is broken into three assessment units: from the confluence with the San Marcos River to 2.5 miles upstream of the confluence with Clear Fork Plum Creek; from that point to 0.5 mile upstream of the crossing with SH 21; and, from that point to the upper end of the segment.

The Upper Plum Creek watershed

The stream begins in an area of rapid development along the IH 35 corridor, between the cities of Kyle and Buda. The stream is made up of flow from several tributaries such as Andrews Branch, Porters Creek and Bunton's Branch. These streams receive wastewater discharges from the city of Kyle's wastewater plant (WWTP), the city of Buda's wastewater plant and several smaller plants that serve new subdivisions just beginning to develop. In the upper portion of the watershed, there are eight wastewater plants that are constructed and currently permitted to discharge a total of over three million gallons per day, the largest facility of which is the city of Kyle's WWTP at 1.5 MGD. Most of these facilities are permitted with future phases that when all the plants reach their final capacity will total over 10 MGD. The permit limits for the majority of the facilities in the upper portion of the watershed are 10 mg/L biochemical oxygen demand, 15 mg/L total suspended solids and 3 mg/L ammonia-nitrogen. The effluents of the city of Buda, and the Sunfield and Shadow Creek developments have limits for total phosphorus of 1.2 mg/L, 1.0 mg/L and 1.0 mg/L respectively. These facilities all utilize chlorine for disinfection.

In addition to urban areas, this portion of the watershed includes agricultural land and areas that have been known to have old, failing or inappropriately built septic tanks, according to the Hays County Environmental Health Office. In addition to these sources of nonpoint source contributions of bacteria, pet waste is considered a source of *E. coli* as well.

GBRA maintains a routine monitoring location in the upper assessment unit located at the crossing of the creek at Plum Creek Road near the community of Uhland. Uhland is not served by a municipal wastewater system at this time. A review of the historical data from the Plum Creek at Plum Creek Road site (site no. 17406) shows trends of diminishing water quality. The most prominent water quality concerns are for nutrient and bacteria concentrations. Figure 1 shows the upward trend in **total phosphorus** concentrations over time. In this figure the inverse relationship between flow and phosphorus can also be seen.

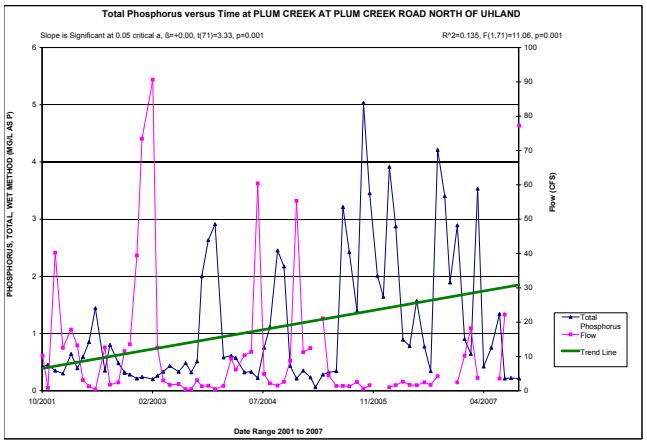

Figure 1. At the GBRA monitoring location at Plum Creek at Plum Creek Road (17406) near Uhland, there is an inverse relationship between flow and total phosphorus.

This relationship exists because the stream is effluent dominated and as more wastewater effluent is added to the creek the phosphorus will continue to rise. The median concentration of **total phosphorus** was 0.56 mg/L, ranging from less than method detection to 5.02 mg/L. 42% of the time the data for total phosphorus fell above the screening concentration of 0.69 mg/L. **Nitrate nitrogen** shows an increasing trend over time (figure 2). The median concentration for nitrate nitrogen was 2.28 mg/L, ranging from 0.22 to 19.8 mg/L, exceeding the screening concentration 50% of the time. Spikes in nitrate concentrations appear to be linked to low flow periods when the stream is effluent dominated. Total phosphorus and nitrate nitrogen are of concern because of the potential for promoting nuisance algal blooms that can deplete oxygen in the stream, especially in the early morning hours, degrading the habitat for fish and aquatic invertebrates.

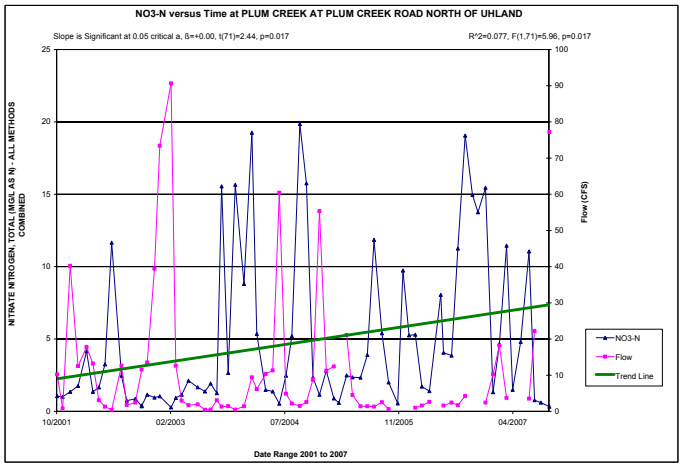

Figure 2. Concentration of nitrate nitrogen showing an increasing trend over time at the Plum Creek at Plum Creek Road (17406). Spikes attributed to periods of low flow when the stream becomes dominated by wastewater effluent.

Ammonia nitrogen exceeded the screening concentration 13% of the time but of more concern was the magnitude of the exceedences. Three of the five sampling events that exceeded the 0.33 mg/L screening concentration for **ammonia nitrogen** were greater than 10 mg/L. Ammonia nitrogen is a concern because of its toxicity to fish. Because of the effluent dominance of the stream, the most logical source of these nutrients is wastewater discharge but other sources of nutrients should be considered such as runoff carrying fertilizers from agricultural fields and lawns and organic wastes from animals such as livestock, pets and wildlife.

This portion of the stream is impaired by fecal bacteria, including ***E. coli***. The geometric mean of the *E. coli* concentrations was 239 organisms per 100 milliliters which exceeds the stream standard for contact recreation of 126 organisms per 100 milliliters. 18 of the 72 sampling events for *E. coli* exceeded the single sample grab standard of 394 organisms per 100 milliliters. The concern for these violations of the stream standard for contact recreation is there but reduced, recognizing the low potential for contact recreation at the site.

The **temperature** ranged from 6°C to 28.1°C at the Plum Creek Road site, with a median temperature of 20.8°C. The **pH** ranged from 7.0 to 8.18, with a median value of 7.81. The median **dissolved oxygen** concentration was 7.27 mg/L, ranging from 2.2 to 14.1 mg/L. The stream standard for dissolved oxygen for this segment is 5.0 mg/L and the minimum dissolved oxygen standard is 3.0 mg/L. The stream was at or below 5.0 mg/L eight times out of 75 sampling events and below 3.0 mg/L four times.

Total suspended solids (TSS) and **turbidity** have an atypical inverse relationship with flow at the Plum Creek Road location (figure 3). TSS can be suspended materials that includes algal cells, organic material and sediment brought in by rainfall runoff from fields and construction sites. A possible explanation for the elevated solids concentrations during the lowest period of flow in 2005 through 2006 could be the increased density of the water due to high dissolved solids which would cause the lighter particles to remain in suspension, to be measured as turbidity and TSS. The median **conductivity** during this period was 1136 umhos/cm. The median conductivity for the entire period of record was 836 umhos/cm, ranging from 404 to 1315 umhos/cm. The increase in dissolved solids during low flows can be attributed to contributions from groundwater sources that have elevated dissolved solids or from wastewater effluent.

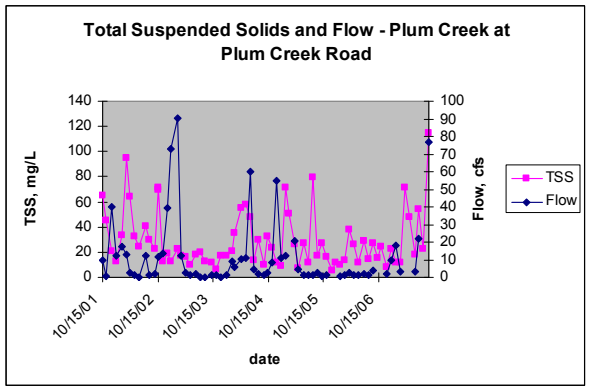

Figure 3. Total suspended solids at the GBRA site located at Plum Creek at Plum Creek Road (17406). Lightweight particles remain in suspension during low flows, possibly due to increase water density with increase in concentration of dissolved solids during these periods.

The Middle Plum Creek Watershed

The water quality of the middle portion of segment 1810, **Plum Creek**, is represented by the data collected by TCEQ at their quarterly monitoring site at CR 202 (site no. 12657), southeast of the city of Lockhart. The middle portion of the creek flows through agricultural cropland, pastureland and the urbanized areas in and around the city of Lockhart. There is some ground water recharge by the stream near the Hwy 183 north of Lockhart. Additionally, it is near this area that oil and gas production begins to become a dominant land use.

The city of Lockhart, as well as Caldwell County, are primed for growth over the next few years as construction of the SH 130 tollway and its spur 45, bring traffic into the area. The Texas Department of Transportation is constructing a mitigation wetland near the creek and Hwy 183. The area will include walking and bike trails, learning kiosks and birding trails. The area is strictly to mitigate lost wetlands during construction of SH130. Water quality was not considered in the design though it will capture flood waters that would normally inundate Plum Creek, and slow water down as it travels through weirs. There is no way to pump water from Plum Creek to supplement the wetlands in times of drought.

The creek receives wastewater effluent discharged from the city of Lockhart's two WWTP, whose combine permitted volume is 2.6 MGD. Neither plant have effluent limits for phosphorus but do have an effluent limit for ammonia nitrogen of 3.0 mg/L. The effluents must meet a carbonaceous oxygen demand of 10 mg/L and total suspended solids of 15 mg/L. The Lockhart Larremore facility, located in the city, uses chlorine to disinfect the effluent. The Lockhart FM 20 facility, located outside the city and upstream of the TCEQ monitoring location, uses ultraviolet light to disinfect the effluent and must analyze the effluent for fecal coliform bacteria daily.

The median **flow** at the TCEQ site at CR 202 (23.2 cubic feet per second) is approximately two times the flow at the upstream site that is monitored by GBRA. Even though there is loss of flow to recharge upstream of Lockhart, the additional flow from groundwater springs that are located in and near the city are sufficient and consistent enough to double the flow at the TCEQ site. These springs, according to local citizens, are not known to go dry, even in driest periods. The springs are thought to originate from the Leona formation that is known for elevated nitrate nitrogen.

The median **conductivity** at the TCEQ CR202 site is 868 umhos/cm, ranging from 43.9 to 1030 umhos/cm. There was a period of six months in late 2001 (3 sampling events ranging from 43.9 to 96.2 umhos/cm) that had unusually low conductivities. There are no recorded flows for those sampling events that can be reviewed to see if stormwater may have diluted background salt concentrations. The median **temperature** at the TCEQ site was 23.2°C, ranging from 11.8 °C to 28.3°C. The median **pH** was 7.9, ranging from 7.33 to 8.2, not falling outside the range of the pH stream standard.

The median concentration for **total suspended solids** was 19 mg/L, ranging from 5 to 502 mg/L. There is limited flow data available but what information

is available shows that the TSS increases with increases in flow associated with storm events. The inorganic constituents, **chloride** and **sulfate**, had median concentrations of 82 mg/L and 78 mg/L respectively, never exceeding the stream standard for these constituents of 350 mg/L and 150 mg/L.

Nitrate nitrogen, ammonia nitrogen, orthophosphate and total phosphorus were measured at the TCEQ site at CR202. The **nitrate nitrogen** was analyzed alone and in combination with nitrite nitrogen. The median concentration was 7.43 mg/L, ranging from 0.49 to 14.2 mg/L and exceeding the stream screening criteria of 1.95 mg/L 24 out of 27 measurements. The sources of the nitrates at this location are most likely the springs that originate from the Leona formation as well as wastewater effluent. **Ammonia nitrogen** ranged from less than method detection to 0.1 mg/L, with a median concentration that was less than method detection. The concentrations that were measured never exceeded the stream screening criteria of 0.33 mg/L.

Figure 4 shows that 50% of the **total phosphorus** measurements were at or above the screening concentration of 0.69 mg/L. The median concentration was 0.685 mg/L, ranging from 0.14 to 1.33 mg/L. The TCEQ also included orthophosphate, which is phosphorus in the dissolved form, in their list of analytes measured at their quarterly site. 17 of the 24 sampling events for orthophosphate exceeded the screening criteria of 0.37 mg/L. The median concentration was 0.64 mg/L, ranging from less than method detection to 1.25 mg/L. Comparing the total and orthophosphate concentration in Figure 4, it appears that in almost every case the majority of the total phosphorus was in the dissolved form, pointing to wastewater effluent or fertilizer, rather than phosphorus associated with algal cells or suspended sediment. Sources of dissolved and total phosphorus include wastewater effluent, storm water that carries in fertilizers and organic material, and failing septic tanks.

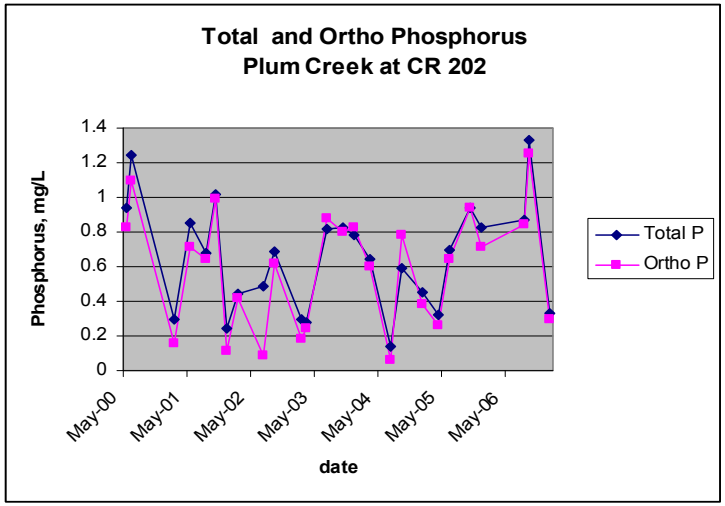

Figure 4. Phosphorus, as total and in the dissolved form, over time at the Plum Creek at CR 202 site (12647). The majority of the phosphorus was in the dissolved form.

Confirming the bacterial impairment identified in the 2008 draft Texas Water Quality Inventory, the geometric mean for **fecal coliform** at the TCEQ site was 231 organisms per 100 milliliters (org/100mL), exceeding the contact recreation standard for fecal coliform of 200 org/100mL. ***E. coli*** was also quantified and the geometric mean (117 org/100mL) came close but did not exceed the standard of 126 org/100mL. Two sampling events for each group of bacteria exceeded the single sample grab standard for the respective parameter.

No sampling events measured chlorophyll a greater than the method detection used by the TCEQ laboratory.

The Lower Plum Creek

The land use in the lower Plum Creek watershed is primarily agricultural crop and pastureland, forests, with a heavy concentration of oil and gas production activities. The only urbanized area is the city of Luling where the creek confluences with the San Marcos River. The city of Luling discharges wastewater to a tributary of the lower Plum Creek. The plant is designed to discharge up to 0.9 MGD, with quality limits of 10 mg/L carbonaceous biochemical oxygen demand, 15 mg/L total suspended solids and 3.0 mg/L ammonia nitrogen. GBRA has had a monthly monitoring site in this portion of the watershed located at CR 135 since 1998. TCEQ has monitored this site and their data was included in the historical review. The 2008 draft Texas Water Quality Inventory listed the lowest assessment unit of the Plum Creek as impaired for bacteria, with a concern for nitrate nitrogen.

The baseflow in the lower portion of the watershed is impacted by saline groundwater. As the stream flow is increased with stormwater and runoff, the concentration of dissolved salts goes down. For example, figure 5 shows the inverse relationship of chloride and flow, with a decreasing trend over time.

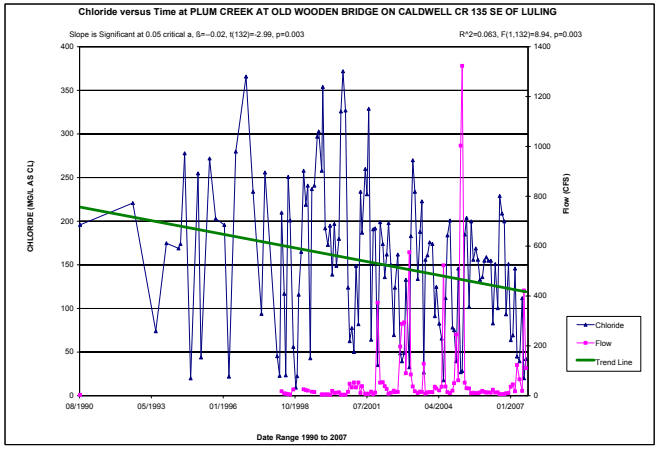

Figure 5. Chloride concentration has an inverse relationship with flow, as storm flows dilute the naturally saline base flow of the lower portion of Plum Creek (12640).

The median **flow** (12 cfs) in the lower portion of the creek is three times the flow at the TCEQ site in the middle Plum Creek, due to the contribution of flow from the West Fork and Clear Fork tributaries that confluence with the Plum Creek in the lower portion of the watershed.

The median **temperature** at the GBRA CR135 site is 22.3ºC, ranging from 6.9ºC to 28.9ºC. The **conductivity** ranged from 146 to 2061 umhos/cm, with a median conductivity of 1233 umhos/cm, 45% higher than the lower two monitoring stations. The **pH** ranged from 7.1 to 8.52, with a median pH of 7.86. The **dissolved oxygen** ranged from 2.5 mg/L to 14.6 mg/L, with a median concentration of 7.24 mg/L. The dissolved oxygen fell below the stream standard of 5.0 mg/L 12 times out of 137 measurements in the historical record, and one time below the screening concentration of 3.0 mg/L. The stream dipped down to 2.5 mg/L dissolved oxygen during one of the lowest flows recorded in the data set.

Total suspended solids ranged from 4 mg/L to 1930 mg/L, with a median concentration of 24.6 mg/L. The highest concentrations of solids are associated with high flows, following storm events as the runoff carries in sediments. The water is hard with a median **hardness** concentration of 313 mg/L, ranging from 65.8 mg/L to 502 mg/L. **Chloride** and **sulfate** concentrations were higher at this site than the other two monitoring sites. The median chloride concentration was 155 mg/L, ranging from 8.5 to 371 mg/L, exceeding the stream standard for chloride two times. Sulfate ranged from 1 to 1030 mg/L, with a median concentration of 81.3 mg/L, exceeding the stream standard for sulfate of 150 mg/L five times.

Nitrate nitrogen, ammonia nitrogen and total phosphorus were analyzed at the GBRA site in the lower Plum Creek. **Nitrate nitrogen** was analyzed alone or in combination with nitrite nitrogen. The median concentration for nitrate nitrogen was 1.59 mg/L, ranging from 0.08 mg/L to 7.69 mg/L, and exceeding the screening concentration of 1.95 mg/L 59 times out of 142 measurements, or 42% of the time. The **ammonia nitrogen** concentration ranged from less than method detection to 0.3 mg/l, with a median concentration of 0.06 mg/L, never exceeding the screening concentration of 0.33 mg/L. Looking at the concentration of ammonia nitrogen over time, we see a significant drop in concentration in 2001. As mentioned in previous basin highlights and summary reports, the elimination of the distillation step from the ammonia nitrogen analytical procedure removed the contamination of the samples by the laboratory atmosphere and reduced the measured ammonia nitrogen in the samples (Figure 6).

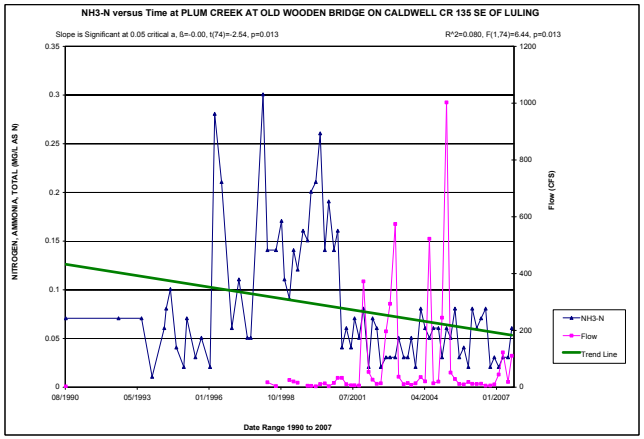

Figure 6. Ammonia nitrogen over time measured at the GBRA monitoring site on Plum Creek at CR 135 (12640). Drop in concentration in 2001 attributed to the removal of the distillation step from the analytical procedure.

Total phosphorus concentrations show a slight downward trend or improvement over time (figure 7). The median concentration of total phosphorus was 0.36 mg/L, ranging from less than method detection to 1.24 mg/L. Ten of the 133 measurements were higher than the screening concentration of 0.69 mg/L, or 7.5% of the time. A possible explanation for the trend could be the increased frequency of analysis in the later years of the historical record.

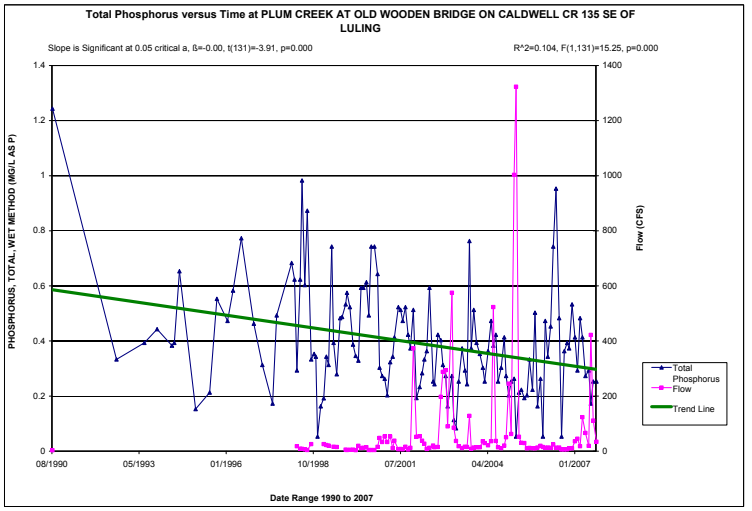

Figure 7. Data at the GBRA monitoring site at CR 135 (12640) shows a significant downward trend in total phosphorus over time that could be explained by an increase in frequency in analyses in the later years of historical monitoring.

During the period of historical data, **fecal coliform** was analyzed and then replaced by ***E. coli***. The respective stream contact recreation standard was exceeded 26 times. The geometric mean for fecal coliform was 168 org/l00mL and the geometric mean for *E. coli* was 108 org/100mL. As expected there is a rise bacteria concentrations with storm flows.

Stakeholder Concerns

The stakeholders that have attended the annual meetings for the Clean Rivers Program Steering Committee as well as those that have commented at other Plum Creek watershed meetings, are concerned about several issues. The issues include the impacts from wastewater effluents, the potential for contamination and spills from unattended oil and gas production facilities, excessive illegal trash dumping in the creek and poorly functioning or failing septic tanks. The Plum Creek Watershed Partnership has recently completed the development of a watershed protection plan that is under consideration by the US EPA. As part of the plan, the members recommended that a compact be entered into by governmental entities and interested parties in the watershed, promoting regionalization of wastewater facilities rather than package plants, the utilization of wastewater for reuse and the increased level of wastewater treatment that includes reduction in nutrient concentrations.